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ENTOM.

DOUGLAS FIR PITCH MOTH.[1]

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NATURE AND CAUSE OF DAMAGE.

Pitch seams, gum check, windshake, or whatever these defects may be termed locally, have ever been recognized as a serious depreciating factor in the utilization of Douglas fir (*Pseudotsuga taxifolia*). These defects have heretofore been variously charged to windshake (mechanical strain), lightning, frost, blazes, fires, and various other unavoidable causes, but investigation of the trouble and its causes makes it evident that the work of the larvæ of the Douglas fir pitch moth (*Sesia novaroensis* Hy. Edw.) is the primary cause of a large percentage of these defects.

DISTRIBUTION AND EXTENT OF DAMAGE.

In the northern Rocky Mountain and Pacific coast regions it has been definitely determined that the Douglas fir pitch moth is responsible for at least 90 per cent of this damage.

A very similar larva,[2] found working in Douglas fir in the southern Rocky Mountain district, makes it quite certain that the same species is responsible for what similar depreciation in timber value may be existing there.

The loss occasioned by the work of this class of insects causes the difference in price between absolutely clear lumber and the lower grades or "dimension stuff." These insects work in the portion of the trunk which later clears itself of branches; hence only logs are affected which, were it not for previous infestation by them, would yield only the better grades of lumber.

Extensive correspondence with mill managers in various parts of the northern Rocky Mountains and Pacific coast range has elicted the fact that no accurate record is kept of the extent of the prevalence

[1] *Sesia novaroensis* Hy. Edw.; order Lepidoptera, family Sesiidæ. Identification by Mr. August Busck.

[2] The insect from the southern Rocky Mountains, after the rearing of three specimens, proves to be *Sesia novaroensis*.

NOTE.—This bulletin is of interest to entomologists as a contribution to their specialty, and to owners and manufacturers as a business proposition.

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of pitch seams in the logs used. But all Douglas fir sawyers estimated a general loss in the entire Douglas fir product of between 7.5 and 15 per cent due to this defect. The depreciation is lowest in the Rocky Mountain region and heaviest toward the coast, evidently corresponding to the respectively slower or quicker growth of the trees in the respective localities and to the relative scarcity or abundance of the moth in these regions.

The writer and his field assistants made a thorough investigation of the logs in the woods and during the sawing of them in the mill, from the manager of which the estimate of lowest loss was received. This mill cuts usually not less than 25,000,000 board feet annually, but the cut during the season 1913–14 was only 14,000,000 board feet. This investigation showed that from 15 to 25 per cent of all the logs in the 14,000,000 board feet had been damaged by the moth. Of the logs clean of branches, in which this sort of damage mainly prevails, fully two-thirds were depreciated in this manner, notwithstanding the fact that those from exposed localities, which are unfavorable to the insect, were practically free from the defect.

The results of the investigation were taken up with the mill manager and it was agreed that the loss in this case constituted but 5 per cent. Yet even this low percentage represented, at the selling price of the lumber at the mill, a loss for that season's low cut of $18,900 to that firm alone. While this percentage is evidently much below the average, it is indicative of what this leak probably means to mills in the entire range of the Douglas fir.

MANUFACTURERS[1] BEAR THE LOSS.

At the present selling price the loss is almost entirely borne by the manufacturer. In the absence of the depreciation, consumers could get the best grades of lumber for the prices they now pay for the cheaper grades, and the manufacturers would besides be able to make a larger clear profit, as they would not have to handle the inferior material from the stump to the lumberyard. There is no help for the lumber now being cut, but the defect is avoidable in the future timber supply. There seems to be no reason, therefore, why the cause should not be eliminated and why mills and lumber consumers should be taxed forever by an insect the work of which involves such extensive financial waste.

SCOPE OF THE INVESTIGATION.

Evidently nothing was known in regard to the larval stages and activities of this insect until the spring of 1913, when, under assignment from Dr. A. D. Hopkins, the writer undertook a systematic study of

[1] By the term "manufacturer" is meant the "saw-mill" man, and by the term "consumer" is meant "contractor, buyer, and builder." A. D. H.

the seasonal history and habits of insects affecting the growth and development of trees, though a number of caterpillars, of what later proved to be this moth, had been caged during the autumn of 1912 for observation. Active cooperation in collecting larvæ and field notes with Messrs. Edmonston, Miller, Burke, Harvey, and all the entomological rangers assigned to the various western field stations from April, 1913, until late autumn, 1914, made it possible to determine not only the insect's distribution, but its comparative abundance and destructiveness in widely separated regions of the Douglas-fir range and also to make this investigation pretty thorough west from the eastern boundary of the State of Montana, toward the coast, and north of latitude 41° 30′ to the boundary of the United States.

LIFE HISTORY.

THE ADULT.

The Douglas-fir pitch moth, like all the members of the Sesiidæ, much resembles, in general appearance, certain wasps and flies. This resemblance is especially strong when the insect is in flight.

The ground color of the insect is black, with rich orange-red spots on the thorax and with all the segments, except the last, banded with the same color. Underneath the whole insect is rich orange-red. Aberrations in color are not frequent but exist, as the rearing of a wholly black female would indicate.

The forewings are transparent, opalescent, with black borders and prominent discal mark; the hind wings transparent, with slight discal mark and narrow black margin. The spread of wings is from 30 to 35 mm., about the size of an ordinary "yellow jacket." The male is about one-third smaller than the female and more slender.

THE EGG.

The eggs are brownish, slightly oblong, and are laid singly. A single female appears to produce slightly in excess of 30 eggs, the issue from two specimens being 34 and 37, respectively. In the field their incubation period is about two weeks.

THE LARVA.

With the exception of the head, which is dark brown, the larva (fig. 1) is white; through the transparent skin the darker intestines and their contents are plainly visible, thus making this larva readily distinguishable from that of *Vespamima sequoia* Hy. Edw., which, to a slight extent, also infests Douglas fir, but which is more robust, has a denser skin, and is dirty white. Especially is this internal dark spot a feature in 1 and 2 year old larvæ, although it is retained to a marked

degree until pupation, which takes place in the third season after the deposition of the egg.

The head is small and rounded; the body cylindrical, rather slender in comparison with that of the larvæ of other sesiids. When full grown it is from 1 to 1½ inches long.

THE PUPA.

The pupa is shining brown, armed with transverse rows of spines on the back of the abdominal segments, by aid of which it moves back and forth at will in the tunnel made by the larva before pupation in the covering pitch mass. When ready for the final transformation the pupa uses these spines for working its way through the thin layer of pitch at the mouth of the tunnel, by projecting its anterior segments to at least one-half of the entire pupal length through the opening, and holding itself securely during the escape of the moth.

SEASONAL HISTORY.

The pupal period as observed in the laboratory is 30 days, but under adverse weather conditions it seems to be prolonged a few days. Usually moths appear in greatest numbers the first sunny day after a rainy spell.

The general emergence of the Douglas fir pitch moth occurs during the month of June, although individuals emerge in Montana as early as May 15, and farther west adults may be found by the first of that month. On May 20 the writer noted the first female (no male was observed at large during two years of observation) flying up and down a Douglas fir tree, evidently in the endeavor to locate a favorable spot for oviposition. Fresh empty pupal shells were observed protruding from pitch tubes on infested trees as early as May 15. A living chrysalis was found early in April, which, allowing 30 days for pupation, would evidently result in adults appearing early in May. It is rather striking that most of the early chrysalids were found at the highest altitudes in which the moth is active. This makes it probable that the shortened seasons at high altitudes are frequently responsible for an extension of the larval period into the fourth year, just as, in consequence of late August oviposition at lower altitudes, a certain percentage of the insects do not attain maturity during the three years that this species requires for development from egg to adult. In such instances the larva pupates during the first warm days of the fourth season. Occasionally adults emerge up to the last of July and the first part of August.

The mature insect lives only about five days after emerging from the pupa, which accounts for its scarcity. Even where its work

proves that it is fairly numerous, it is only by good fortune that one gets a chance to observe its behavior. During two seasons of judiciously chosen days and locations for observations the writer saw but six specimens in the forest. They were all females, and each of them was apparently engaged in oviposition. While the insect swiftly wings its way up and down the tree trunk, the eggs are deposited, either at the edge of a wound or a perfectly smooth spot, oftener the latter, and only a single egg is deposited at each place.

In Montana, where the insect is not exceedingly numerous, the writer and Entomological Rangers Swartz, Wagner, and Fleming examined hundreds of trees, each of which displayed comparatively fresh, healed-over wounds, unquestionably of sesiid origin, but in no case was more than one larva of each of the triennial generations found at the same time in the same tree. This suggests that if there is an abundance of suitable trees for infestation a female, after depositing one egg only on a tree, leaves the latter, repeating the same operation until its supply of eggs is exhausted. Consequently quite a number of trees are thus affected by a single female.

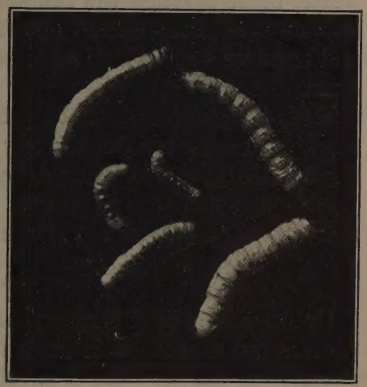

FIG. 1.—Three generations of larvæ of the Douglas fir pitch moth (*Sesia novaroensis*). Natural size. (Original.)

From Ashland, Oreg., where the insect is much more abundant than in the Rocky Mountains, Mr. Edmonston reported as many as 6 larvæ, all of which proved to be of the same generation, from a single tree, and Mr. B. T. Harvey states that quite a number of trees in the coastal region are scarred from base to near the tops by the work of this moth.

I have no doubt that this apparent discrepancy in ovipositing is due solely to the fact that in regions where the insect is nearly ten times as numerous as in the Rocky Mountains several females by chance deposit eggs upon the same tree; in fact, they are compelled to do so, unless they are willing to oviposit on trees that are undesirable on account of growth.

By August 1 young larvæ from the June oviposition, upon close examination of the infested trees, may be readily located by the boring dust, which resembles that of *Dendroctonus pseudotsugae* Hopk. This dust is produced by the larva eating its way through the outer bark into the cambium. At the end of the first active season a pitch tube covers the wound as well as the larva which made it.

During the second season the larva merely maintains and enlarges the established chamber or tunnel, and, growing in size, as far as was possible to ascertain, molts the first time when 1 year old. The third season is passed like the second, the larva molting once again when two years old. By the end of this period the covering pitch tube is about the size of a silver dollar, depending somewhat on the shape of the wound inside.

The third spring after deposition of the eggs the larva, now nearly three years old, is ready to pupate. During the last two years the larva changes but little in size; the younger is somewhat more slender if of the same length as the older. The older larva, however, has become so thick skinned that it appears almost entirely white, while through the thinner skin of the younger generation the reddish intestines are still plainly visible. It is not a simple matter and requires a great deal of experience to separate these two generations.

With the exceptions noted for high altitudes and late oviposition, exactly three years after the egg was laid the adult appears, completing the life cycle and making the generation of the species triennial.

Although there are no seasons in which this insect is very abundant there are none in which it is unusually scarce.

HABITAT.

Unlike others of this group of insects, the Douglas fir pitch moth prefers the shade. It is most numerous in from 10 to 50 year-old Douglas-fir stands with a northerly exposure, and is consequently most injurious there. So-called "spruce swamps" are as much avoided as are the sun-exposed hillsides. While it may also be found to some extent on sunny slopes having a stand of trees sufficiently dense to provide practically constant shade, it is usually only trees which have been injured by some other cause which are here infested first. The insect is evidently attracted here from the preferred localities by the smell of pitch, just as barkbeetles are attracted by the smell of felled or fire-scorched timber.

It may be noted here that larvæ under pitch tubes which are much exposed to the sun are almost invariably killed during the winter months. Evidently the larva can not survive when kept active by the warmth of the sun while its sustenance is cut off by frost. This may probably explain why this insect is not numerous under conditions which expose it much to the influence of the sun. The pitch tubes of *Sesia novaroensis* and the bark of Douglas fir at the usual points of infestation do not provide the protection against the indicated influence as do, for example, the big pitch tubes and the bark of yellow pine for the larvæ of *Vespamima sequoia*, which survive under any exposure, presumably on account of this protection.

LOCATION OF AFFECTED AREAS.

The Douglas fir pitch moth has apparently a very marked habit concerning the preferred areas in given localities. An area in which it is depreciating the timber now may be readily located by simply watching the logs at the mill as they go through the saw and ascertaining where those with pitch seams come from. It may seem a matter of speculation to undertake to determine localities where the insect is numerous at present by thus examining trees which have been infested a century or more in the past, but it has been ascertained to be an absolutely reliable method. The success of this test not only proves that the sesiid is the cause of the depreciation, but it shows us in addition how we may determine the exact localities where the merchantable timber is liable to serious damage by the insect, because wherever the injury exists in the young, growing timber, which will be "loggable" a hundred years from now, it is practically certain that the mature trees had been afflicted in the same manner in their youth.

RANGE OF THE INSECT.

As already indicated, the range of this insect is over the northern Rocky Mountain and Pacific Coast regions and extends in all probability through the entire native range of the Douglas fir. From my own observations and numerous field notes and from larvæ collected in various parts between the northern boundary of the United States and latitude 41° 30′ N. and from the eastern boundary of the State of Montana to the western coast by other members of the Branch of Forest Insects and kindly put at the disposal of the writer, it is evident that the moth is most abundant in the western part of its range, a conclusion which in turn is verified by the losses estimated by millmen in the various sections of this area.

HOST TREES AND CHARACTER OF INJURY.

(Figs. 2–5.)

Douglas fir (*Pseudotsuga taxifolia*) is evidently the special host of this moth. However, although unable successfully to attack previously uninjured larch (*Larix occidentalis*) it breeds also and thrives well in blazes and other wounds on that tree, particularly in the pitch flow caused by a fungus, identified by Dr. James R. Weir, of the Bureau of Plant Industry, as *Trametes pini*. A great number of fungus-infested larch in a stand of timber may make this tree a real menace to the Douglas fir in the same area.

The healthier and quicker growing a Douglas fir may be, the more it appears to be subject to infestation by the moth. Trees are attacked when about 10 years old and after that until they are about

50 years old, when the bark has roughened and thickened to an extent to render it practically immune. However, on many trees the bark over previous sesiid wounds is frequently in a condition which invites reinfestation, and thus larvæ are often found in trees which are ready for logging. Especially is the latter a frequent occurrence, if, as a result of the circular pitch seam inside, caused by the moth many years ago, the tree is split by wind strain from that seam straight to the surface of the bark. Toward the end of the first-year work of the larvæ, usually about August, the effect of

FIG. 2.—Work of the Douglas fir pitch moth: Evolution of pitch blister and pitch seam. (Original.)

their presence is shown in the growth of the new layer of wood, which is restricted immediately above and below and to some extent on the sides of the wound. Pitch formation in this new layer of wood and in the underlying layers, in an attempt by the tree to protect itself, forms the nucleus of the pitch blister. The inflexibility of this blister, even if the timber is but normally swayed by the winds as the tree grows taller, is bound to cause a further parting of the tissues and ultimately results in the pitch seam, which so greatly depreciates the value of the logs as lumber material. The afflicted tree endeavors, during the three years required by the larva to develop to adult, to wall up the wound, and the larva tries to maintain its established position; this struggle results in the wound

becoming rather deeply embedded in the woody tissue. From then on it depends upon the growth of the tree whether only the pitch blister at the base of the wound is to be inclosed in the healthy tissues or whether the pitch from the pitch tube and bark also is to be inclosed. As a rule, a tree of slow growth heals from the inside and the injury is less apparent, whereas a tree of rapid growth puts forth such a quantity of new growth over the injured spot that clean healing is impossible and a serious defect is evident almost immediately,

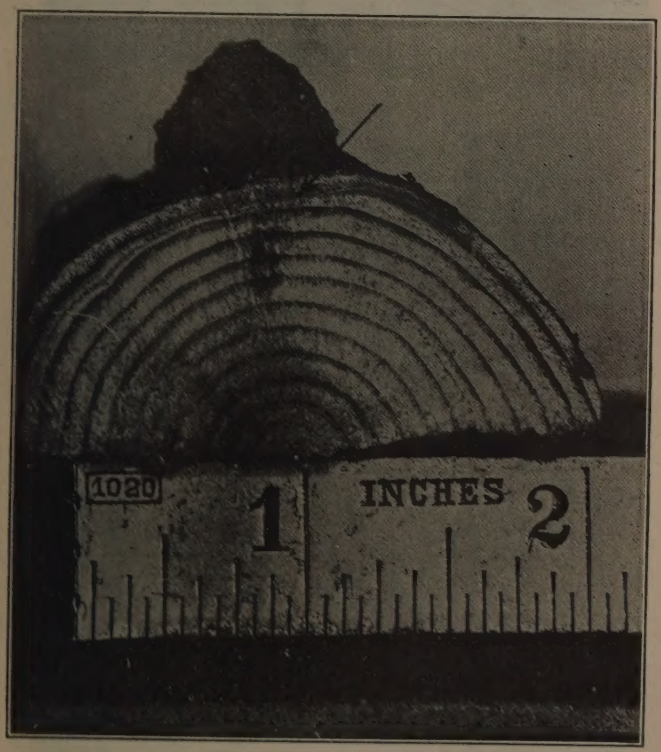

FIG. 3.—Work of the Douglas fir pitch moth: Effect of infestation on the wood growth 2 inches below (and above) the wound the first year after attack. (Original.)

even without the added aggravation of mechanical wind strain. The effect of mechanical strain during succeeding seasons upon trees afflicted with serious wounds from the very beginning renders them unfit as lumber material.

The real depreciation of the future saw log is inflicted while the trees are less than 50 years old, and most of the pitch seams, which result more or less in a separation of the inner and outer tissues, are caused by the insect when the trees are quite young. While the

original wounds made by individual specimens may be several feet apart on the trunk of a tree, as the latter grows taller and is swayed by the wind the inflexible blisters are gradually lengthened and widened and finally united. In trees which had been infested on all sides the seams are entirely circular, while in those infested on one

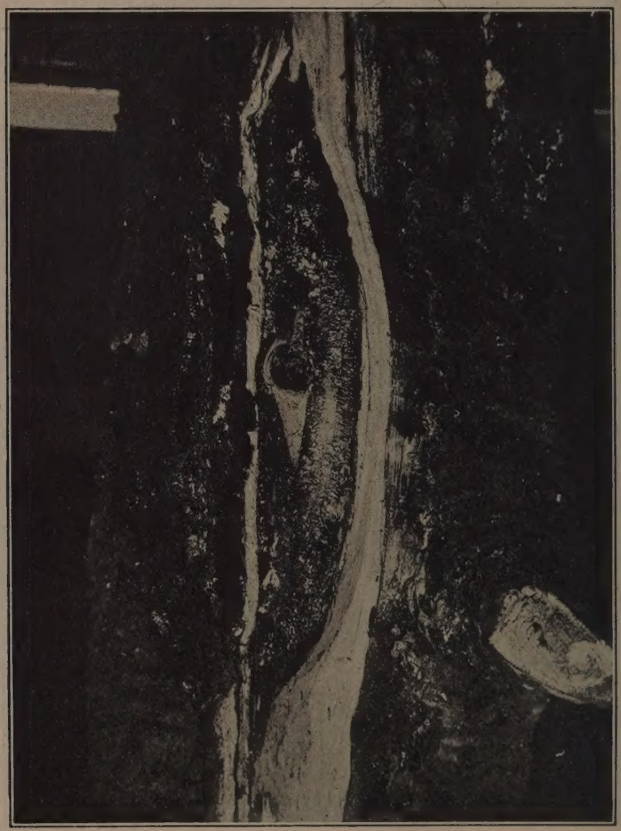

FIG. 4.—Work of the Douglas fir pitch moth: Pitch blister two years after emergence of moth, with tissues which had already grown over it perfectly, removed at one side. Natural size. (Original.)

side only, a frequent occurrence, the seam is semicircular. However, the cause which underlies both these effects is the same.

EVIDENCE THAT IT IS INSECT WORK.

(Figs. 6–8.)

Full-blown pitch seams probably never pass into lumber, and affected parts of logs are either converted into small "dimensions,"

laths, or firewood. Therefore to illustrate them adequately it would be necessary to split tree trunks, often for the length of several logs, to show a side view of an entire seam, and even if this were accomplished successfully the result would be merely something like a board which had been split and had been loosely stuck together again. With the exception of figure 2, showing the evolution of

FIG. 5.—Wound caused by the Douglas fir pitch moth. Photographed soon after emergence of moth. Natural size. (Original.)

the pitch seam, the photographs used to illustrate the injury to Douglas fir by pitch-moth infestation are from material from which the insect emerged so recently that the cause of the wounds is obvious. Such injury within the tissues of a coniferous tree is never eliminated in the course of years, but rather becomes accentuated when the split of the tissues is later extended for the length of many feet by mechanical strain.

WINDSHAKE AND LIGHTNING NOT THE CAUSE OF PITCH SEAMS.

The contention that windshake is capable of causing pitch seams in perfect tissues of this tree is not tenable when the facts at hand are considered. If this were true, freely exposed trees should contain the greater number of pitch seams, and those in sheltered positions should have few or none, which is not the case. Also, Douglas

FIG. 6.—A cross-cut showing wound caused in a young tree by the larvæ of the Douglas fir pitch moth. Reduced. (Original.)

fir is generally recognized to be of more tenacious fiber than larch, as is frequently illustrated in timber-sale contracts, which provide for the "butting" of the latter trees over a certain size, on account of depreciation in that part of the tree by "genuine windshake." To the knowledge of the author timber-sale contracts contain no such clause or even a similar clause concerning Douglas fir. While in the larch, recognized to be subject to windshake, owing to brittleness, the damage by windshake extends but a few feet above the base, in the admittedly tougher Douglas fir the damage from supposed "windshake" frequently runs up to 60 and more feet. "Wind-

shake" in larch above a few feet from the ground is practically nonexistent, since this tree, more than any of our conifers, is, if healthy, immune to insect attack, except to the foliage, and, if attacked, is more able to repulse the onslaught from the outset.

"Lightning" has been included in the same category with "windshake" as a cause of pitch seams in Douglas fir. The theory that lightning is a causative agent refutes itself by mere examination of the damaged material. It is the lower two-thirds of the tree trunks which are seriously pitch seamed, while the upper part is almost invariably free from the defect, and it is not reasonable to assume

FIG. 7.—Development of a "pitch seam" only four years after the emergence of the Douglas fir pitch moth. Note the enormous growth the tree put forth to cover the wound. Greatly reduced. (Original.)

that the electric spark would persistently leave the tops untouched and so frequently injure only the part below the branches.

Another point in this regard is the fact that judging from the location of the seams in the trunks the trees could not have been of very great size when the defect occurred. A casual stroll in the woods will convince the most heedless observer that it is not the younger trees which are most subject to lightning.

It is evident from the foregoing that infestation of a tree by the Douglas fir pitch moth does not result in immediate financial loss.

This has to be borne by future generations, just as the present is paying for the damage inflicted by the insect a century or more in the past.

Actual tally of sesiid wounds, blazes, bullet wounds, bruises by blasting, etc., all of which cause blister effects in wood tissue, was

FIG. 8.—An embryo pitch seam caused by the Douglas fir pitch moth only a few years after emergence of moth: *A*, Pitch blister which the larvæ caused before emerging; *B*, a break in the tissues by wind strain on account of the defect; *C*, break filling with pitch; *D*, inclosed pitch from pitch tube which caused imperfect healing; *E*, parts of pitch tube which covered the larvæ, still part of the surface covering. Reduced. (Original.)

made in a stand of Douglas fir about 30 years old, where conditions were most favorable for the operation of all the latter causes. This tally demonstrated that in this area of about 30 acres the sesiid wounds averaged, up to 15 feet from the ground, a little over 96 per cent, while the wounds from all other causes combined represented less than 4 per cent. Wounds above 15 feet could safely be consid-

ered almost entirely due to moths, but they were not counted. If they had been counted the percentage of all other factors would not have exceeded 1 per cent, and this in a location more or less unfavorable for the moth.

CHARACTER OF LARVAL WORK.

(Figs. 9–10.)

If trees have been injured the eggs are evidently deposited by the moth at the edge of wounds, regardless of their origin, and the larva

FIG. 9.—Tunnel at the end of the first active season of the larvæ of the Douglas fir pitch moth. Natural size. (Original.)

begins feeding at such places. The larva apparently follows the line of least resistance, because the resulting tunnel is likely to assume any shape in such cases. On perfectly sound trees the egg is evidently deposited where the bark is absolutely smooth and fresh, and the larva feeds upon the bark as soon as it slips out of the eggshell. This is apparently also the reason why trees with thick bark are attacked only where sesiid or other partially healed wounds provide conditions which answer the same requirement.

After the young larva has penetrated to the cambium, which usually occurs about August, or at a time when the growing period of the tree for the season is ended, it excavates a tortuous tunnel from 1 to 2 inches in length, parallel with and transverse to the grain of the wood. The length of the tunnel at completion depends largely upon the growth of the infested tree. In slow-growing trees

FIG. 10.—Pitch tube covering larvæ of the Douglas fir pitch moth the second year after infestation. Natural size. (Original.)

it reaches occasionally a length of from 5 to 6 inches at the time of moth emergence, while in very vigorous growers the larva maintains its well-being within a circular-shaped pit, not more than 2 inches in width, deeply embedded in the woody tissues of the cambium.

The surface of the wound is invariably covered by a pitch tube of the color of the bark. When the outer crust of the tube is removed it is found to contain pitch and the excreta of the larva. If the same wound is reinfested, soft pitch mixed with the old crusty pitch

usually indicates the presence of the larva. Plural infestation under one pitch tube has not as yet been observed.

It is only upon very close examination of the tree that the infestation will be revealed, so perfect is the blending of color of the Douglas-fir pitch and the bark, notwithstanding the fact that the covering pitch tubes are about 2 inches in diameter and protrude at least 1 inch from the surface of the bark. The protuberances so much resemble a knobby growth that considerable experience is necessary to enable one to distinguish them at sight.

The attack is restricted to the main trunks of trees, the first, second, third, and fourth logs being usually most affected, the injury becoming notably absent above 60 feet from the ground.

Trees are never killed outright, although very vigorous trees, if attacked several seasons in succession, become so weakened that their originally less robust neighbors easily outgrow them.

RELATION TO OTHER DESTRUCTIVE INSECTS.

In most localities where the Douglas fir pitch moth is present Douglas fir and larch trees are to be found with dead bark on the trunks in strips several inches wide and often more than 20 feet long. This peculiar injury, except in the case of Tetropium in larch, is usually attributable primarily to fires, bruises by falling trees, and perhaps, to some extent, lightning. Examination of these strips under the bark usually reveals sesiid larvæ, or at least abundant traces of their work. The galleries under the bark contain, in addition, the unmistakable evidence of beetle infestation. In all such cases coming under the writer's observation these beetles of the genera Melanophila or Tetropium were found to have infested the trees primarily or after they had sustained the mechanical injuries before mentioned, and to have been the agents which prepared favorable propagating places for the moth. Extended observations lead the writer to believe that these and similar beetles do not follow the moth, but that the moths occasionally adopt the galleries, etc., of the beetles.

A few trees which had been outstripped by their companions, evidently on account of previous moth infestation, were noted as subsequently killed by *Scolytus unispinosus*, but, considering that these trees when killed by the beetles were already worthless as timber producers, the interrelation of moth and beetle in this instance seems of no economic consequence.

Vespamima sequoia[1] is another very injurious pitch moth which infests Douglas fir in old wounds and branches, and especially wounds

[1] Brunner, Josef, The Sequoia pitch moth. U. S. Dept. Agr., Bul. 111, 11 p., 5 fig., July 11, 1914.

originally made by *Sesia novaroensis*, thus extending the injury. In Montana it infests wounds in the trunks of Douglas fir to the extent of about 1 per cent. But in the vicinity of Ashland, Oreg., Vespamima appears to have developed a special liking for this tree. Fully 10 per cent of the pitch-moth larvæ sent me by Messrs. Edmonston and Miller from Ashland proved to be *Vespamima sequoia*. According to the accompanying notes, all of the larvæ of this species were collected in wounds previously made. At Placerville, Cal., a single larva of Vespamima was collected in Douglas fir, and this was in an old wound.

Wounds in Douglas fir, especially those made by the pitch moth, presumably on account of their better protective character, are usually infested for several seasons by the larvæ of a small moth of the genus Laspeyresia.[1] Two or three larvæ are frequently found around the edges of a single wound. The Laspeyresia also attacks young Douglas fir at the base of branches independently, and, although the attack itself usually does no permanent injury, the resulting accessibility to the cambium often induces infestation by the Sesia. That the work of Sesia is responsible for the increasing numbers of Laspeyresia, by providing favorable conditions for propagation, seems a reasonable conclusion, yet it is doubtful if the abundance or scarcity of Laspeyresia similarly affects the pitch moth, which is well able to establish and sustain itself.

RELATION TO NATURAL ENEMIES.

In localities where *Sesia novaroensis* is more than commonly numerous nearly 20 per cent of its larvæ are killed before reaching maturity by a tachinid parasite.[2] The influence of this parasite as a check on the numbers of Sesia or as lessening the depreciation of timber appears from a strictly economic standpoint to be practically nothing, since it appears from extensive observations that only those moth larvæ under imperfect pitch tubes are subject to attack by the parasite. As the greater number of pitch tubes form an impenetrable barrier against the parasite, there is little reason to expect that it will ever be a factor in the control of the pitch moth.

MEANS OF CONTROL.

In determining control measures for use against the Douglas fir pitch moth five readily accessible areas were selected for detailed investigations. On all of these the stand of timber was mixed and the conditions were those which obtain in almost any location west of the Rocky Mountains, excepting the pure pine stands. The results

[1] Identification by August Busck, Bureau of Entomology.
[2] Identification by C. T. Greene, Bureau of Entomology.

of the investigations and experiments (Table I) made it evident that to accomplish any permanent good under general forest conditions it is best to extend control over large areas. In Project III, for example, where the infestation is in general rather slight, collecting was done within a 5-section limit over 460 acres only, in strips containing a stand of trees of a character more susceptible to attack, and while the destruction of the larvæ resulted in some reduction of the annual infestation, it could not in any sense be regarded as an important factor in reducing the ultimate depreciation of the timber without the application of constant attention.

TABLE I.—*Control of the Douglas fir pitch moth: Projects and results.*

Project No.	Damage.	Sections.	Acres.	Larvæ collected.		Remarks.
				1913	1914	
I	Medium...	5	3,200	790	74	To June; from August to December, 8 larvæ found in area. Collected thoroughly.
II	Serious....	.....	30	101	5	Thorough search.
III	Slight.....	5	460	94	53	From 1913 oviposition.
					16	From 1914 oviposition. Collected during December. Collecting done in strips of reproduction within the mature stand.
IV	Heavy....	.....	40	207	9	From 1913 oviposition.
V	Serious....	.....	10	41	2	From 1912 oviposition.

Project No.	Age of stand.	Local conditions.
	Years.	
I	10–40.....	Surrounded by older stand; hills and flats alternating.
II	30.....	Northern exposure; practically isolated, except for adjoining stand of mature timber.
III	120, with strips of reproduction from 10 to 40 years old.	Heavy mountain forest in a solid stand which extends for miles.
IV	40.....	Creek bottom; flat surrounded by steep hills stocked with 10-year-old and younger reproduction.
V	15–20.....	Practically isolated, being surrounded by yellow-pine stand free of any sesfid.

In Project I, which also covers five sections, the larvæ were destroyed throughout, and during the autumn of 1914 but 8 larvæ were found near the border of the area. In Project I a daily inspection at the proper period in the year along the border would be amply sufficient to protect the entire area from a serious infestation until such time as the trees shall have outgrown the danger stage.

The principle of "isolating" stands susceptible to infestation should be the potent factor in control of this insect. Let us take a practical example of what is meant by isolation in this regard. Two streams, distant from each other in an air line say a couple of miles, run parallel from their source at the base of a mountain to the open farm lands, but between them is, as usual, a dividing ridge. Along both streams, in favorable locations, the moth is equally numerous, yet elimination of the moth along the entire length of one stream

means the practical dissociation of it from its neighbor, because the dividing watershed line invariably provides unfavorable conditions for moth existence on one slope. (See Habitat, p. 6.) No matter in which direction a stream may flow, one slope of the watershed is always subject to a greater degree of sunlight than is favorable to this insect. Again, a sufficiently wide strip of trees other than Douglas fir on the opposite side of a stream may safely be regarded as a buffer, as was indicated in the results of investigations in Projects II, IV, and V. Project V was an almost pure stand of Douglas fir which was connected with the next nearest solid block of Douglas fir, about 1 mile distant, by a few stragglers of this fir through the solid stand of surrounding yellow pine.

Small tracts, which can be given attention for a few days annually, may be kept comparatively free of infestation and, even if infested, the removal of the larva during the first year of its life will prevent the development of the wound to the serious stage. Of course the infestation, even for only a year or less, will leave a pitch spot in the tissue, just as is produced in case of unsuccessful Dendroctonus beetle attack or the infestation by bark maggots, but the result will not be nearly as serious as when the larva is left in the tissue to complete its life cycle. From the investigation it also developed that one experienced man could practically clean and keep clean an area 50 miles square or, roughly, 1,600,000 acres of this class of damage within a few years. The long period of three years that is required for the insect to develop from egg to adult is a decidedly strong factor in the case of its control. Considering the amount of annually "loggable" Douglas fir from such an area under the mixed-stand conditions that ordinarily obtain, and the percentage of depreciation wrought by the insect, the employment of such caretakers would appear to be a good investment, even if there were no other insect problems requiring the attention of the men.

If in the future lumbering interests are not to pay the same tax to the pitch moth of our time as is now contributed, due to the depreciation of timber a century and more ago, the present day is the time to aid in the elimination of this pitch moth.

As is apparent from the foregoing text relating to the larva and to the seasonal history of the moth, two generations of larvæ, excluding the overlapping percentage at high altitudes and from late oviposition, may be found at any time of the year. For example, by July 1, 1915, the issue from the 1912 oviposition will have emerged and between that date and September 1, when the pitch tubes produced by the issue of the 1915 oviposition are sufficiently developed to be readily seen, only larvæ from the 1913 and 1914 issue are to be found. From September 1 until June 1, 1916, when the 1913 issue

will emerge, 3 generations, those of the issues of 1913, 1914, and 1915, may be located and destroyed at one time. However, no matter how close the examination, a few infested pitch tubes will always escape notice. It is therefore advisable that the same area be scouted several times in the course of each season. After an area is once cleared it should not be a difficult task to keep the insect in check and much the less so if control projects cover big sections.[1]

Destruction of the larva is the only remedy that can be used to reduce an infestation. When the infested pitch tube is located, it should be separated from the tree, the thus exposed larva killed, and to insure cleaner healing the ragged edges of the wound should be smoothed with a knife or small ax, after which they should be painted with creosote or a similar preparation, to prevent reinfestation by insects or fungi. The enlarging of the wound by the smoothing of its edges will also leave a pitch blister in the tissues, but the ultimate result will not be nearly as disastrous as from the untreated sesiid wound, since a clean healing from the inside obviates much of the chance of its producing a circular seam. Freshly vacated wounds might be treated the same way with profit.

SUMMARY AND CONCLUSIONS.

That the financial loss caused by *Sesia novaroensis* in Douglas fir product is great and represents a greater leak in profits to manufacturers than any other avoidable item is evident.

That the depreciation for which this age is taxed can be eliminated for the benefit of posterity at an expense so low that it is but a fraction of that which the damage represents seems to be sufficiently demonstrated by the results of the investigations and experiments.

The manufacturer will always bear the greater extent of the loss, and the manufacturing interests should inaugurate the elimination of the insect by putting into effect a policy of paying better prices for timber where it is clear of pitch seams and reducing the price commensurately for material where logs are defective to an appreciable extent, instead of paying a uniform amount of so much per thousand feet in a locality, without consideration of existing conditions. This would create among owners of forest lands a stimulus to produce clear timber, free of pitch seams, by a little attention annually, and even if the immediate desire should be merely the obliteration of the evidence on young trees by which the defect in the merchantable material is determined, for the purpose of deceiving the lumber cruisers, it would nevertheless produce the desired end.

[1] Under "Habitat" and "Host Trees and Character of Injury" is suggested where to look for infested trees.

On account of the long life cycle of the Douglas fir pitch moth its elimination, in any country where forestry is sufficiently advanced to be a profitable business and where the forests are taken care of as they should be in order that they may be profitable, will follow. In the range of the Douglas fir there are millions of acres of forest land which are inaccessible and practically worthless at the present day, but they will remain so not much longer, and with advanced methods in forestry *Sesia novaroensis* is bound to disappear ultimately. The process of its eradication will necessarily be slow, but this is no reason why a systematic policy to attain this result should not now be adopted in areas which have been and are being logged and which, it is certain, will be logged again when the reproduction attains merchantable size.

While in this paper only the more serious result of pitch-moth infestation during the first 40 years' growth of trees is considered, it does not mean that the insect does no damage in older and mature trees. As is seen under "Host trees," it infests these also under favorable conditions, but in such cases the infestation results only in the so-called "gum spots," the pitch blisters being too near the surface of the trees to cause serious breaks and ultimate "pitch seams" by mechanical strain in the part of the tissues rendered inflexible. In regard to the "gum spots" in Douglas fir, which entail practically no loss to mills, but for which the builder and consumer foots the bill entirely, the pitch moth is responsible for not more than 10 per cent, *Dendroctonus pseudotsugae* for not less than 70 per cent, and all other causes for about 20 per cent of the damage.

SYNONYMY.

Aegeria novaroensis Henry Edwards, Papilio, v. 1, 1881, p. 199; Grote, New Check List N. Amer. Moths, 1882, p. 12; Beutenmüller, Bull. Amer. Mus. Nat. Hist., v. 4, 1892, p. 172.

Sesia novaroensis Smith, List Pepid. N. Amer., 1891, p. 20; Beutenmüller, Bull. Amer. Mus. Nat. Hist., v. 8, 1896, p. 133; Beutenmüller, Memoirs Amer. Mus. Nat. Hist., Monograph of the Sesiidæ of North America, 1902, p. 289.

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